NAVGEM Platform Support

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LONG-TERM GOALS

The long-term goal of this ONR project is to prepare the technical framework for the associated ONR DRI on "Unified physical parameterization for seasonal prediction" which aims to develop generalized physical parameterizations that will enable a global prediction system useful for forecasts out to seasonal time scales. Targeted specifically at improving/extending the forecast capability of the Navy Global Environmental Model (NAVGEM; a successor to NOGAPS with new dynamical core and advanced physics) from weather prediction to seasonal prediction, potential PIs of the DRI will be able to work collaboratively and efficiently on model physics development using the technical framework developed by this project.

OBJECTIVES

The objective of this project is to offer support (e.g., consultation, code updates and version control, data transfer, user feedback collection and implementation, etc.) for users of NAVGEM who obtain the system through the release of the code as determined by release guidelines. One of the primary objectives of this proposal is to establish a more comprehensive technical support capability for the NAVGEM users, particularly those who have projects supported by ONR. The distribution of NAVGEM to the scientific community will be accomplished by Naval Research Laboratory (NRL)-Monterey whose functions include, but are not limited to, making incremental improvements to the website, updating versions of the code as necessary, updating the NAVGEM documentation, providing user feedback to NAVGEM developers, and providing atmospheric and surface initial and boundary condition data for forecast model simulations.

APPROACH

The Navy global forecast system is continuously upgraded and a recent significant milestone is the operational transition of improved physics and a semil-Lagrangian dynamical core. The focus of the ONR DRI is on the development of the physical parameterizations to improve the weather prediction skill of NAVGEM and to extend its capability to seasonal prediction. Further improvement can be achieved by efforts from broader community dedicated to work on Navy's modeling framework. We are building a centralized and automated code access system to distribute the software efficiently and effectively. This web-based system will have a two-tier infrastructure (Figure 1). NRL researchers have access for the Tier 1 system containing the operation version of NAVGEM and the NAVDAS-

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AR data assimilation system (Figure 1, whole diagram). Outside collaborators and PIs of the DRI will have access to the Tier 2 access to the NAVGEM software only (Figure 1, green blocks) and sets of initial and boundary forcing fields, as well as the validation data set. As the first step, a single-column version (SCM) of the model physics will be distributed for evaluating the physical parameterizations and upon completion of the evaluation of the SCM the distribution of the whole forecast model will follow. The key personnel are Mr. Tim Whitcomb (PI) and Dr. Tim Hogan (the primary NAVGEM developer who will help with SCM development). Dr. Jim Ridout, who is the PI of the ONR DRI project on "Unified physical parameterization for seasonal prediction", will play an advisory role.

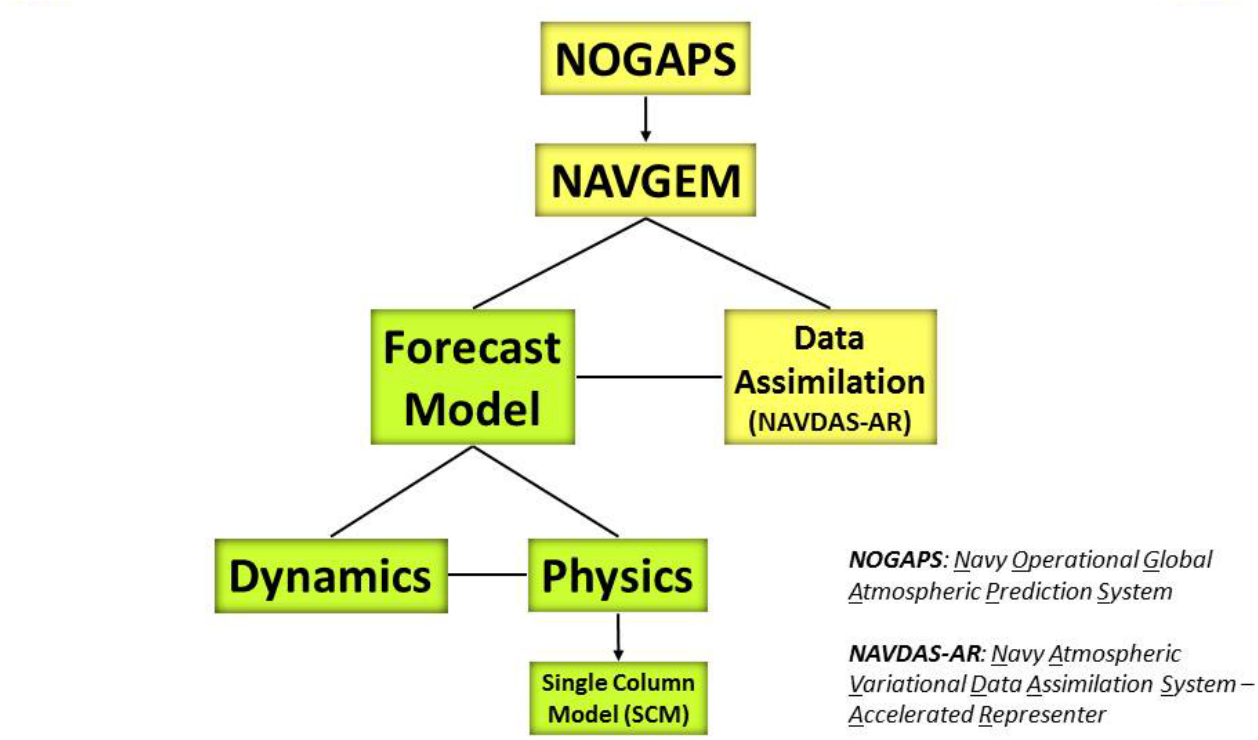

Figure 1. NAVGEM 2-Tier Access System. Tier 2 system (denoted by green), which consists of the model physics component (together with the dynamics component needed to integrate the model in time) and its single column model (SCM) version will be available for external collaborators, whereas the Tier 1 system, which also include the rest of the model components (denoted by yellow and green, i.e., the whole system), will be available for internal developers only.

WORK COMPLETED

- Evaluated new parameterization for turbulent air-sea fluxes
- Evaluated eddy-diffusivity/mass flux (EDMF) parameterization for boundary layer mixing
- Transitioned NAVGEM upgrade including EDMF parameterization to FNMOC
- Continued development of internal Subversion system for NAVGEM.
- Continued development of a framework for displaying model diagnostics for the full NAVGEM model.
- Prepared source code management system designed for external collaboration.

- Released NAVGEM single-column model to DRI collaborators.

RESULTS

Two new parameterizations were evaluated from DRI collaborators. The first is a modified formulation for turbulent air-sea fluxes from DRI PI Dr. Edgar Andreas (NorthWest Research Associates). An initial version of his code was adapted for use in NAVGEM.

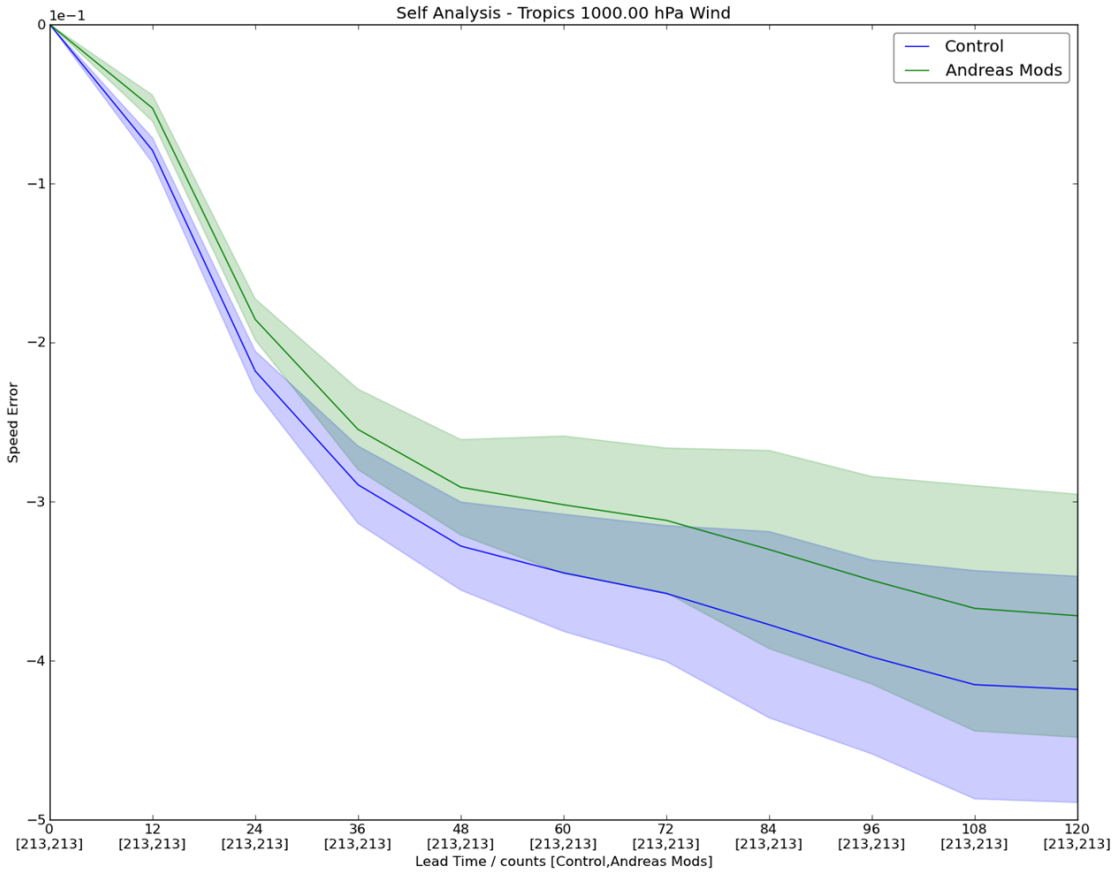

Figure 1 – Mean 1000 hPa tropical wind speed error for the summer 2012 evaluation period. The blue line shows the control configuration and the green line shows the model including the modified air-sea flux parameterization. This shows the speed bias is more negative in the control case, so the modification is an improvement. The shaded region shows a 95% confidence interval for the mean value. Analysis of paired differences indicates that this improvement is statistically significant (using a 95% threshold).

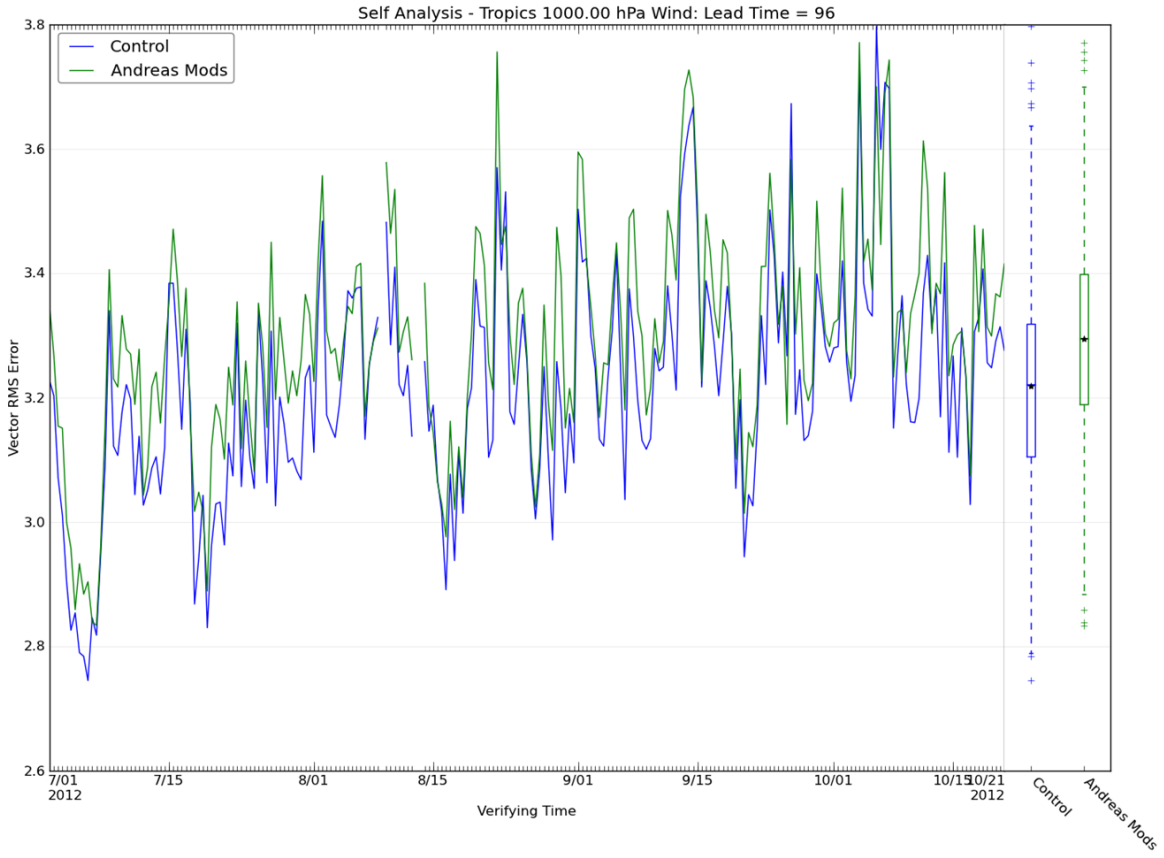

Figure 2 – Timeseries of 1000 mb vector RMS wind error for 96-hour forecasts verifying during summer 2012. The blue curve shows the control configuration and the green curve shows the modified air-sea flux configuration. The structure of the error tracks very closely, but the modifications introduce higher RMS error at all verifying times (not shown). Analysis of the paired differences shows that this degradation is statistically significant (using a 95% threshold).

The air-sea flux parameterization was tested for Summer 2012. While there were some significant improvements (see Figure 1), the modification did lead to a degradation of some metrics. In particular, the vector RMS error was higher after the modification (see Figure 2), suggesting higher variability or perhaps a direction bias introduced by the scheme relative to the control. These metrics are also computed versus a verifying analysis instead of against observations. As research under the DRI continues, new versions of this turbulent flux parameterization are under development and will also be tested the same way.

The second parameterization evaluated was an eddy-diffusivity/mass flux (EDMF) formulation from DRI PI Dr. Joao Teixeira (JPL) and colleagues. This parameterization aims to incorporate the effects of thermals in vertical boundary layer mixing in addition to parameterizing local turbulent processes. Since NAVGEM already incorporates an eddy-diffusivity method for vertical mixing (using the bulk Richardson number), testing the EDMF parameterization required adding the massflux component to NAVGEM.

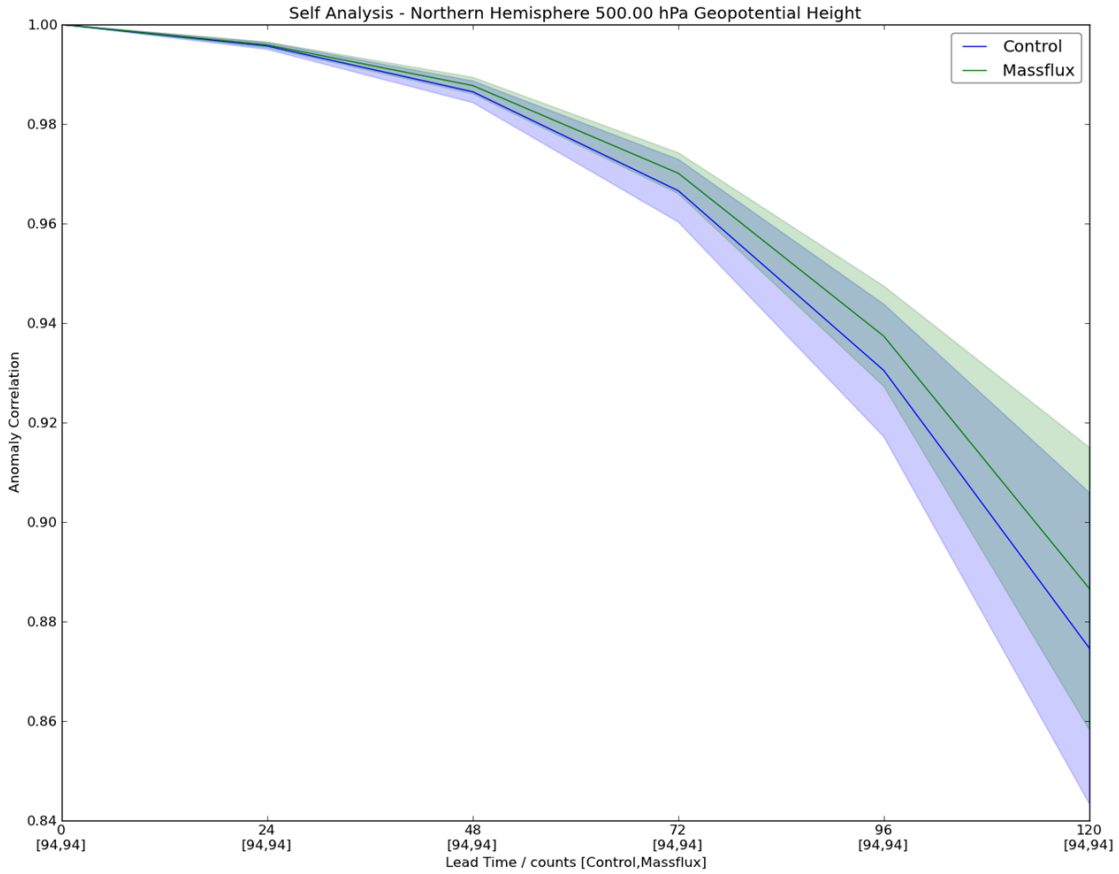

Figure 3 – Mean 500 mb geopotential height Northern Hemisphere anomaly correlation for a several-month evaluation period. The blue line shows the control configuration and the green line shows the modified configuration adding the massflux to the eddy-diffusivity-based parameterization. The shaded regions show the 95% confidence interval about the mean. Analysis of paired differences shows a statistically significant (at 95%) improvement at all lead times.

Adding the massflux component to the vertical mixing resulted in significant improvements for multiple metrics, in particular the Northern hemisphere 500 mb geopotential height anomaly correlation (Figure 3) which has traditionally been a challenging measure to improve. Other metrics (such as upper-air temperature biases) were also improved. These improvements led to wider testing of the model version with the EDMF scheme and a transition of the upgraded NAVGEM system to FNMOC for OPTEST in Summer 2013. Modifications to the EDMF scheme by DRI PIs are also under way and will be tested as they become available.

To aid further parameterization development by DRI collaborators, we released a single-column version of NAVGEM to DRI PIs – this model features the same model physics routines used in the full 3-D NAVGEM system, but reduced to a single vertical stick. This allows the model to run quickly on a workstation using forcing data from the full 3-D model to assess the impact of various changes to the physical parameterizations.

The Git version control system is designed for distributed teams, and is of particular interest since it can function without direct network connectivity between collaborators. The NAVGEM SCM was distributed using this tool and will allow external users to both track revisions in their own work, but will primarily serve as a means of simplifying updates from NRL to DRI collaborators as well as facilitate incorporation of their changes to the NAVGEM source code.

Regardless of the version control system used with collaborators, the main NAVGEM repository used by NRL Monterey developers resides in Subversion. This year we continued internal user training and process refinements to help make the model development process smoother and to deal with frequent updates as several versions of NAVGEM were transitioned. Maintaining this internal system is a critical part in ensuring a path for NRL Monterey developments to be distributed to external collaborators and has already proved helpful in collaborations with the NRL Space Science Division in Washington, D.C. (including scientists funded by this DRI).

Since the development of any model parameterization relies on validation and verification, we continued development of a framework for displaying user diagnostics. Most of the work focused on the full modeling system but these advances will be useful to individual developers in a single-column model framework as well. Unifying the diagnostic output between NRL Monterey and developers will make identification of promising modifications simpler and allow for improved communication between

IMPACT/APPLICATIONS

Provide convenient access to the NAVGEM model code and data for external users, and promote scientific discussions of the results obtained from their research, leading to the synergic development of the model physics.

RELATED PROJECTS

“Unified physical parameterization for seasonal prediction” (ONR DRI)

PUBLICATIONS

T. Whitcomb, 2013: Navy global forecast system, NAVGEM: Distribution and user support. 3rd Scientific Workshop on ONR DRI: Unified Parameterization for Extended Range Prediction, 23–25 July 2013, Monterey, California, USA.